as consisting of "a body and a soul held together by the spirit, which is the cause and the law." "To grasp the invisible elements, to attract them by their material correspondences, to control, purify, and transform them by the living power of the spirit—this is true alchemy." The pure, invisible, intangible, universal elements constituted the highest of the three orders of things; the second order was composed of "elements that are compounded, changeable, and impure, yet may by art be reduced to their pure simplicity"; and the third order contained the "twice compounded elements" which served as vehicles for drawing down the pure ethereal elements and fixing them in the substances of the second order. The laboratory was the place for learning the properties of the things of the second order; "for from these proceed the bindings, loosings, and transmutations of all things." Paracelsus speaks of the three substances of which all things are composed; these three things are "sulphur, mercury, and salt"; but he adds, "they are acted on by a fourth principle which is life." "These three substances," he says, "are not seen with the physical eye. . . . If you take the three invisible substances, and add the power of life, you will have three invisible substances in a visible form. . . . They are hidden by life, and joined together by life. . . . All things are hidden in them in the same sense that a pear is hidden in a pear tree and grapes in a vine. . . . A gardener knows that a vine will produce no pears, and a pear-tree no grapes"

I think it is possible from these extracts to construct, in a general way, the non-natural scheme of nature that was upheld by Paracelsus. A great deal may be said in its favour, if only we agree to construct the nature that is to be explained from our own consciousness with closed eyes. This certainly may be asserted in favour of the so-called spiritual science of Paracelsus and the mystics of his school, that their method is infinitely easier than the method of natural science, or, as it is called by the modern Paracelsians, materialistic and sceptical science. Whatever judgment may be passed on natural science when it is contrasted with supernatural mysticism, it is at any rate ludicrously erroneous to say that the former is proud, dogmatic, and conceited, while the latter is humble, suggestive, and ready to learn. The answer to the conception of the universe that Paracelsus framed is to be found in the history of science, and in the history of humanity, since the Middle Ages.

But however radically a modern naturalist may differ from the mediæval alchemist, he must recognise the great debt which those who to-day seek the knowledge of natural laws owe to the man of the sixteenth century who boldly declared against authority, and besought his followers to go to nature, who insisted on the interdependence of the various branches of natural knowledge, who taught the essential unity of the forms of matter and of the forms of energy, and who, by his discoveries in medicine, helped forward the blessed work of alleviating the miseries and soothing the sorrows of human beings. Whatever else he was, Paracelsus was certainly a true man; he lived earnestly; he was not regardful of the conventionalities of life; he received blows, and he returned them; he suffered much, and he bore his troubles on the whole with patience and some nobility. With his own words we may leave him:—"Have no care of my misery reader; let me bear my burden myself. I have two failings: my poverty, and my piety. My poverty was thrown in my face by a Burgomaster who had perhaps only seen Doctors attired in silken robes, never basking in tattered rags in the sunshine. So it was decreed that I was not a Doctor. For my piety I am arraigned by the parsons, for I am no devotee of Venus, nor do I at all love those who teach what they do not themselves practise."

M. M. PATTISON MUIR.

ON HOLLOW PYRAMIDAL ICE CRYSTALS.[1]

I. *THE Lava Cavern of Surtshellir.*—The lava cavern of Surtshellir forms a long subterranean channel—over a mile in length—in the post-glacial lava-field which encompasses in a vast semicircle the ice-covered Eyríksjökull (Iceland). The farthest recess forms a chamber about 30 feet high, and from its floor and ceiling spring ice-stalagmites and stalactites of rare beauty. (Fig. 1.)

The north-western wall is gracefully draped by a long curtain of icicles resembling somewhat the pipes of an organ. From those parts of the vault not covered by icicles a thousand glitterings and sparklings are seen, at every movement of the candle, to be reflected from ice crystals which stud the walls.

The ice crystals have the form of hexagonal funnels, or hollow hexagonal pyramids. In size they range up to two inches long, with a hexagon side of half an inch. The triangular sides of the pyramids are built of most delicate steps of ice, arranged in the manner of a staircase.

The attachment is invariably by the apex, and the hexagonal bases turn trumpet-like towards the interior of the cave. (Fig. 2.) When these observations were made in June 1892, the temperature of the air in the cave was $+0\cdot5^\circ$ C.

There are some minute cracks in the roof of the cave, through which water trickles scantily. At such places *icicles* are formed, but not crystals. The crystals are not formed from the water percolating into the cave, but from the moisture contained in the air, and as such they must be regarded as a kind of *hoar-frost*.

II. *Hoar-frost.*—During Christmas week 1892 an unusually fine hoar-frost prevailed over the North of England. In various parts of Yorkshire, Lancashire, and Cheshire, we found the rime to consist almost entirely of hexagonal "hopper" crystals. (Fig. 3, *a*, *b*, *c*.) The basal hexagons varied up to about $\frac{3}{8}$ inch in diameter, and the majority of the crystals measured in height about twice the diameter. (Fig. 3, *a*.) Some, however, were more obtuse. (Fig. 3, *b*.) The forms were often obliquely truncated (Fig. 3, *c*), certain faces having grown more rapidly than others. A spiral arrangement was noticed in some cases, and occasionally a double spiral resembling the helix of an Ionic capital. (Fig. 3, *d*.)

There was a marked tendency for the simple pyramids to group themselves into compound forms. (Fig. 3, *e*, *f*.) The groups exhibited hexagonal outlines (Fig. 3, *f*), and the primary pyramids on the periphery were, as a rule, better developed than those in the interior. The secondary hexagons often measured more than $1\frac{1}{2}$ inches in diameter. Even a tertiary grouping could be made out in a few cases. In a few rare instances the primary hexagons were studded at the corners with small hexagons resembling bastions. These bastions were either solid or hollow. (Fig. 3, *g*.)

III. *Crystals under Ice-Crusts.*—On January 3, 1894, we found in Cheshire, during a severe frost, similar hexagonal hoppers on the under-surfaces of ice-crusts covering hollow spaces over ruts in clayey soil, or covering ponds where an air-space divided the ice from the water. No ice crystals were found on the sides and bottom of the ruts, and there was no trace of *hoar-frost* on adjacent objects.

These observations suggested the idea that *hoar-frost might be made at will* on any cold night. We accordingly spread pieces of black cardboard and black velvet over grass, and on examining these after two days of hard frost we found the *under*-surfaces coated with an abundance of hollow pyramidal and other forms of ice crystals. No hoar-frost formed on the upper surfaces of the velvet or cardboard, and none existed on the grass.

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[1] From a paper read before the Royal Society, by Dr. Karl Grossmann and Joseph Lomas.

IV. *Artificial Hoar-frost.*—Experiments had been planned before Christmas 1892, for the artificial production of hoar frost. It was thought advisable, before completing our arrangements, to search for any possible traces of hoar-frost in the refrigerating chambers used for the frozen-meat trade in Liverpool. This visit rendered experiments unnecessary, as it yielded a rich harvest of simple and compound forms of hollow pyramidal crystals. All the variations observed in natural hoar-frost were met with, and the details of the forms were registered by microphotographs taken with magnesium light The ice chambers were cooled down to −13° C.[1]

Very large and beautiful simple hoppers were obtained from ships used in the frozen-meat trade. During the four to six weeks of transit from the River Plate to Liverpool the hold is cooled down to about −5° C., and the enclosed air is perfectly calm.

FIG. 1.—Ice Stalagmites in the Lava Cavern of Surtshellir (Iceland).

On the occasion of a visit to Berlin, in June 1893, the large cooling cellars connected with the "Muenchener Brauhaus" were examined (by kind permission of Director Arndt), and small hopper crystals were discovered on the cooling pipes.

V. *Comparison with other Skeleton Crystals.*—The simple hollow hexagonal pyramids of ice naturally suggest comparison with the well-known cubic "hopper" crystals of rock salt and skeleton crystals of other substances.

In crystal-building there is always a marked tendency towards excessive growth along the diagonal axes of the crystal. At the angles of crystals there is, for a given area, a larger supply of material for growth than in the middle of a side. Beautiful skeleton crystals of potassium chloride can be formed by rapidly cooling concentrated warm solutions. First, a great number of micro-crystals are formed, which float about in the brine. Any of these may form a centre of attraction round which crystalline matter will aggregate. A small cube will form the centre, and from each solid angle a straight axial row of small cubes will arise.[1] The intervening parts will gradually get filled up if sufficient time is allowed.

This type of skeleton crystal is evidently due to *overgrowth.*

Quite differently formed, though with the same result, are the hopper crystals of sodium chloride. NaCl is almost equally soluble in cold and hot water. Unaffected by cooling, it will therefore crystallise out of brine most rapidly where the concentration becomes greatest through evaporation, viz. at the surface. Suppose, then, a single cube to be formed at the surface. Beginning to sink, there will be deposits of fresh cubes on the four upper edges of the cube in the form of a step. This goes on until we have a floating hollow pyramid, apex downwards. At the corners of these hoppers additional cubes are formed. (Compare the analogy with the hexagonal form, Fig. 3, *g*.) These skeleton crystals are due to *growth at the upper edges of floating crystals.*

A third type of hollow skeleton crystals we have in hoar-frost.

When crystallisation of atmospheric vapour takes place in absolute freedom, we find the crystals mainly developed in a plane perpendicular to the principal axis, as *flat* snow crystals. When, however, the atmospheric space is limited by a wall, first a small hexagonal disc of ice attaches itself to that wall. Then, as growth proceeds, in a calm or comparatively calm medium, the middle portion of the disc will be in contact with air robbed of its moisture, while the edges will grow outwards, the rate depending on the amount of food material. The open ends of the funnels will point towards the middle of the wall-bound air-chamber or cavern, or away from the wall; in the case of hoar-frost the funnels will be open towards the sky.

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[1] Our thanks are due to Mr. Ward for permission to work in the chambers of the Sausinena Company, and to Mr. Lintott, through whose help we were enabled to exhibit some of the ice crystals at the soirée of the Royal Society.

[1] See A. Knop. "Molekularconstitution und Wachsthum der Krystalle," p. 52. (Leipzig: 1867.)

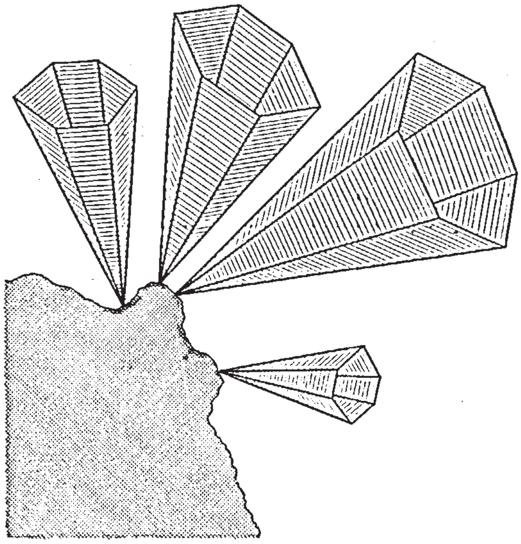
FIG. 2.—Hollow Hexagonal "Hopper" Crystals of Ice found in Surtshellir. (Natural size.)

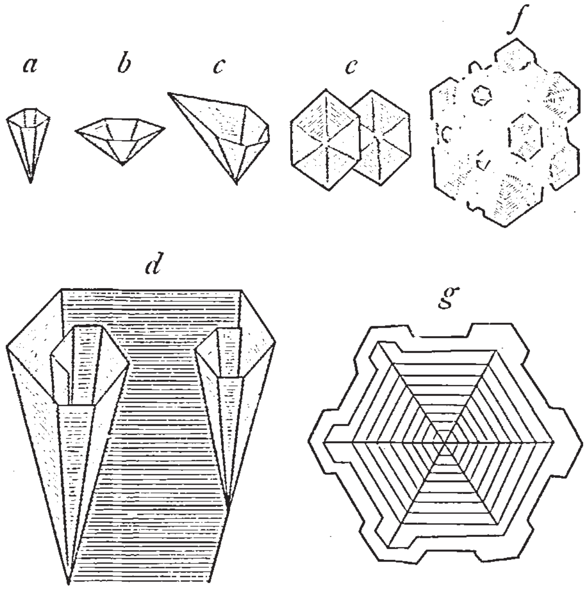

FIG. 3.—Natural Hoar-frost (Christmas 1892). (*a* and *f* natural size; *b*, *c*, *d*, *e* and *g* enlarged.)

This type of skeleton crystal may be termed *starvation crystal*.

By reflections from the steps seen on the triangular faces of the pyramids, we were able to show that they consist of combinations of faces of the hexagonal prism (∞ P) and the basal pinacoid (O P).

VI. *Literature.*—In 1697, Camerarius of Tübingen ("De figura nivis et pruinæ." *Misc. ac. natur.* Jenæ, Dec. 1697, p. 480) describes some hoar-frost on the lead bindings of windows as hexagonal discs, some of which had a central depression.

Dr. J. Krenner mentions, in his description of the ice cave of Dobschau ("A Dobsinai Jegbarlang." Budapest, 1874), flat hexagonal ice crystals, some depressed in the middle, or obtusely funnel-shaped.

In a paper entitled "Eine Krystallgrotte" (Groth's *Zeitschr. für Krystallographie*, 1888, xiv. p. 250), C. A. Hering mentions and illustrates fan-shaped ice crystals which probably are identical with those seen by Krenner, except that they are quite flat. On the upper surface of the fans some hexagonal hopper-shaped ice crystals were found.

VII. *Conclusions.*—(1) Water when changing direct from the gaseous into the solid state is highly crystalline.

(2) The tendency to crystallisation is so strong that in those cases where the area of supply is limited by a wall or other surface, skeleton crystals—hexagonal "hoppers"—are formed, growing away from the wall, even under circumstances of excessively slow growth.

(3) Calmness of air seems to be an essential condition for their formation.

(4) From our observations there can be no doubt as to the identity of the ice crystals of Surtshellir, of the refrigerating chambers and ships in Liverpool, and of the cooling cellars of the Berlin breweries, with natural hoar-frost.

THE GLACIAL SYSTEM OF THE ALPS.

ON the day following the close of the Sixth International Geological Congress an excursion, organised and conducted by Profs. Penck of Vienna, Brückner of Berne, and Dr. L. du Pasquier, left Lugano to visit the chief glacial deposits of the Alps. An excellent guide-book of permanent interest, entitled "Le Système Glaciaire des Alpes," had been prepared by the conductors of the excursion.

On the first day (September 17) the party, numbering thirty-five, took train to Sesto Calende, and descending the Ticino in boats, walked over the moraines of Lago Maggiore to Borgo Ticino. An excellent view of the morainic amphitheatre, which forms a loop round the southern end of the lake, and rises to 470 feet above its level, was obtained from the morainic Monte del Bosco. In the evening the party proceeded to Ivrea by rail.

Next day was spent in examining the celebrated moraines of Ivrea, which testify so eloquently to the size of the glacier that descended the valley of Aosta. From the northern morainic ridge (the Serra), which rises to a mean elevation of 1300 feet above the central depression, a good view of the great amphitheatre was obtained. Late at night Milan was reached.

On the 19th train was taken to Lonato at the southern end of the Lake of Garda, whence carriages were taken to Salò, on the western shore of the lake. On the way to Salò, most interesting evidence of three successive glaciations was seen. It is found that the moraines of the last glaciation show only a very thin weathered crust, whereas the moraines of the two previous glaciations are marked by a weathered crust called "ferretto," many feet thick, in which the pebbles, even of granite and gneiss, are so much decomposed as to be readily cut with a knife. The whole weathered crust has assumed a deep red-brown rust colour, whence the Italian name for it.

At Mocasina the unaltered lower part of a moraine of the second glaciation was seen overlying the much-weathered "ferretto" crust of a moraine of the first glaciation. At Benecco the unaltered moraine of the last glaciation